Addendum to EPA's *Biological Evaluation for the Issuance of Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll* a *for the Chesapeake Bay and Its Tidal Tributaries.*

November 3, 2010

INTRODUCTION

In April 2003, the U.S. Environmental Protection Agency (EPA) issued the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries* (EPA 903-R-03-002). That document established the applicable water quality criteria to protect the designated uses of the Chesapeake Bay.

Prior to issuance of that document, EPA and the National Marine Fisheries Service (NOAA Fisheries) engaged in a formal consultation under the Endangered Species Act (ESA). EPA's "Biological Evaluation for the Issuance of Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and Its Tidal Tributaries" dated April 25, 2003, determined that the only endangered or threatened species in the Chesapeake Bay watershed that would potentially be affected is the shortnose sturgeon (*Acipenser brevirostrum*). The evaluation further found that the water clarity and chlorophyll *a* criteria would not likely adversely affect, and would indeed beneficially affect listed species in the Bay.

NOAA Fisheries responded with a Biological Opinion (BO) dated April 19, 2004, which addressed all threatened and endangered species under NOAA Fisheries jurisdiction, but focused on the effects of the dissolved oxygen criteria on endangered shortnose sturgeon. It was NOAA Fisheries' biological opinion that the issuance of the Chesapeake Bay criteria by EPA may adversely affect the population of endangered shortnose sturgeon through displacement to suboptimal habitat or other behavioral and metabolic responses to hypoxic conditions but is not likely to jeopardize the continued existence of the Chesapeake Bay population of shortnose sturgeon or the species as a whole. The BO also included an Incidental Take Statement (ITS).

Since 2003, EPA has issued a number technical support documents and addenda to the April 2003 criteria (Appendix A). On September 24, 2010, EPA issued a draft Chesapeake Bay Total Maximum Daily Load (TMDL), which utilizes the EPA's dissolved oxygen criteria as the basis for determining the allocations. The purpose of this addendum to EPA's April 2003 Biological Evaluation is to evaluate any impacts to shortnose sturgeon from the EPA's modifications to the dissolved oxygen criteria resulting from addenda, and the establishment of the final TMDL.

EPA's April 2003 Biological Evaluation and NOAA Fisheries April 2004 Biological Opinion

On April 25, 2003, EPA issued the Biological Evaluation for the Issuance of *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries.* In that evaluation, EPA determined that the regional criteria for water clarity and chlorophyll a criteria will not likely adversely affect Federally listed threatened and endangered species. EPA further determined that the dissolved oxygen criteria will not likely adversely effected listed species in the Chesapeake Bay, with the exception of the shortnose sturgeon. However, collective application of the dissolved oxygen criteria is fully protective of shortnose sturgeon survival and growth for all life stages. The adoption, implementation and eventual full attainment of the states adoption of the EPA recommended dissolved oxygen criteria will result in significant improvements in dissolved oxygen concentration in the Bay and beneficially affect shortnose sturgeon. Therefore, EPA concluded that the recommended dissolved oxygen criteria for the refined Chesapeake Bay designated uses will not adversely affect the continued existence for shortnose sturgeon in the Bay.

NOAA Fisheries responded to EPA's evaluation through a Biological Opinion (BO) on April 19, 2004. NOAA Fisheries found that the water clarity and chlorophyll *a* criteria are expected to improve water quality conditions in the Bay and its tidal tributaries, beneficially affecting all native species of the Bay, including shortnose sturgeon. With regards to shortnose sturgeon and dissolved oxygen, the opinion concluded that while the dissolved oxygen levels authorized by the criteria may result in some short-term adverse affects to shortnose sturgeon, no chronic or lethal effects were expected, and significant protections were being provided to essential habitat. Also, "the adoption of the dissolved oxygen criteria will result in significantly improved water quality conditions in the Bay, elimination of anoxic zones and the improvement in the quality and quantity of habitat available to shortnose sturgeon as well as improving the chances for shortnose sturgeon recovery in the Bay and improving the likelihood of long-term sustainability of this population."

It was NOAA Fisheries' BO that the issuance of the Chesapeake Bay criteria by EPA may adversely affect the population of endangered shortnose sturgeon through displacement to suboptimal habitat or other behavioral and metabolic responses to hypoxic conditions but is not likely to jeopardize the continued existence of the Chesapeake Bay population of shortnose sturgeon or the species as a whole.

The biological opinion included an incidental take statement. NOAA Fisheries' ITS determined that EPA's issuance of the criteria was reasonably certain to result in incidental take of shortnose sturgeon. Generally, shortnose sturgeon are adversely affected upon exposure to dissolved oxygen levels than 5 mg/L and lethal effects are expected to occur upon even moderate exposure to dissolved oxygen levels of less than 3.2 mg/L. Due to the ability of shortnose sturgeon to avoid hypoxic areas, take was determined to likely be as harassment.

Based upon EPA modeled data, take levels were estimated for each of the designated uses where take is anticipated (open water, deep-water and deep-channel). Take was determined to likely occur only in the summer months (June 1 – September 30), and the area of the Bay designated uses that failed to meet a 5 mg/L monthly average dissolved oxygen level, further refined using "tolerate" habitat thresholds for temperature, salinity and depth, was used as a surrogate for take of shortnose sturgeon by harassment.

The ITS concluded with reasonable and prudent measures offered to minimize incidental take. Terms and conditions for EPA to comply with in order to be exempt form the prohibitions of Section 9 of the ESA were also provided.

EVALUATION OF THE POST-2003 CHESAPEAKE BAY WATER QUALITY CRITERIA AND DESIGNATED USE RELATED DOCUMENTATION AND ADDENDA

In April 2003, the EPA published the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries* (EPA 903-R-03-002) (*Regional Criteria Guidance*) and completed ESA consultation on the criteria and the contents of the *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability* (EPA 903-R-03-004, October 2003). Since the Biological Evaluation was completed, EPA has issued a number of subsequent addenda to the *Regional Criteria Guidance* and the Technical Support Document (TSD) with the intent of refining the criteria and its implementation. It is the purpose of this section to evaluate how issuance of those subsequent documents may impact shortnose sturgeon due to the dissolved oxygen criteria established levels.

The *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries – 2004 Addendum* (EPA 903-R-03-002) was issued in October 2004. This document addressed several issues. Specifically regarding dissolved oxygen criteria and its application, this document provides guidance to jurisdictions on where and when to apply the open water dissolved oxygen criteria of 4.3 mg/L instantaneous minimum to protect the survival of the shortnose sturgeon; guidance on assessing attainment of the minimum and 7-day mean dissolved oxygen criteria pending development of statistical models; guidance on derivation of site specific dissolved oxygen criteria in tidal wetlands; and, guidance on upper and lower pycnocline boundary delineation methodology. EPA finds that this guidance does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, nor does it significantly modify the intended application of the criteria as specified in the 2003 documents. Therefore, EPA finds that the issuance of the October 2004 criteria addendum will have no effect on shortnose sturgeon beyond that already consulted upon and concluded in April 2004. There will be no further evaluation of this guidance in this document.

The October 2004 *Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability – 2004 Addendum* (EPA 903-R-04-006) the majority of this document addresses SAV and shallow water habitat. It does also address refinements to Bay tidal waters designated use boundaries and segmentation boundaries. EPA finds that this guidance does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, nor does it significantly modify the intended application of the criteria as specified in the 2003 documents. Therefore, EPA finds that the issuance of the October 2004 TSD addendum will have no effect on shortnose sturgeon beyond that already consulted upon and concluded in April 2004. There will be no further evaluation of this guidance in this document.

The October 2004 *Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983-2003* (EPA 903-R-04-008. CBP/TRS 268-04) details documentation on the history of the segmentation schemes and coordinates, georeferences and narrative descriptions of the 2003 segmentation scheme. The December 2005 *Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983-2003: 2005 Addendum* (EPA 903-R-05-004. CBP/TRS 278-06) then addresses the methods used to subdivide the segments by jurisdiction and the coordinates, georeferences and narrative descriptions for those subdivided segments. Segmentation is the compartmentalizing of the estuary into subunits based on selected criteria. It is a way to group regions having similar natural characteristics, so that differences in water quality and biological communities among similar segments can be identified and common stressors and responses elucidated. Segmentation does not modify the dissolved oxygen criteria for the open water, deep-water or deep-channel, nor does it significantly modify the intended application of the criteria as specified in the 2003 documents. Therefore, EPA finds that the issuance of the segmentation scheme documents has no effect on shortnose sturgeon, and there will be no further evaluation of the segmentation schemes in this document.

In July 2007, EPA issued the *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries – 2007 Addendum* (EPA 903-R-07-003. CBP/TRS 285-07). In this addendum, EPA addressed the revised, refined, and new criteria assessment methods for the Bay water quality DO, water clarity/SAV and chlorophyll *a* criteria. The criteria attainment assessment procedures published in this addendum replace and otherwise supercede similar criteria assessment procedures originally published in the 2003 *Regional Criteria Guidance* and the subsequent addenda. EPA finds that this guidance does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, nor does it significantly modify the intended application of the criteria as specified in the 2003 documents. Therefore, EPA finds that the issuance of the July 2007 addendum will have no effect on shortnose sturgeon beyond that already consulted upon and concluded in April 2004. There will be no further evaluation of this guidance in this document.

In the 2003 Regional Criteria Guidance, EPA published a suggested narrative statement to address chlorophyll a criteria. In November 2007, EPA published *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries* – 2007 Chlorophyll Criteria Addendum (EPA 903-R-07-005. CBP/TRS 288/07) which included a set of numerical chlorophyll *a* criteria for Chesapeake Bay and supporting criteria assessment procedures. This document does include a discussion on the relationship of chlorophyll *a* levels to dissolved oxygen impairments to determine whether there is a significant quantitative relationship between chlorophyll *a* and dissolved oxygen, and whether it would be useful in developing chlorophyll *a* numeric criteria. Specifically regarding dissolved oxygen, the documents concludes that meeting the chlorophyll *a* reference concentrations specified in this document will contribute to achievement of desired dissolved oxygen concentrations. However, the document does go on to state that in the Chesapeake Bay's current eutrophic state, relationships between the accumulation of chlorophyll *a* and oxygen depletion are not likely to yield useful numeric chlorophyll *a* criteria. Based upon this conclusion, EPA finds that this guidance does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, nor does it significantly modify the intended application of the criteria as specified in the 2003 documents. Therefore, EPA finds that the issuance of the November 2007 Chlorophyll Criteria Addendum will have no effect on shortnose sturgeon beyond that already consulted upon and concluded in April 2004. There will be no further evaluation of this guidance in this document.

The September 2008 *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries – 2008 Technical Support for Criteria Assessment Protocols Addendum* (EPA 903-R-08-001. CBP/TRS 290-08) addresses refinements to the Bay water quality DO, water clarity/SAV and chlorophyll *a* criteria assessment methodologies and documents the 2008 92-segment scheme for Bay tidal waters. EPA finds that this guidance does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, nor does it significantly modify the intended application of the criteria as specified in the 2003 documents. Therefore, EPA finds that the issuance of the September 2008 TSD addendum will have no effect on shortnose sturgeon beyond that already consulted upon and concluded in April 2004. There will be no further evaluation of this guidance in this document.

Finally, in May 2010, EPA issued *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tidal Tributaries – 2010 Technical Support for Criteria Assessment Protocols Addendum* (EPA 903-R-10-002) which addresses refinements to procedures for defining designated uses, existing procedures for deriving biologically based reference curves for DO criteria assessment and chlorophyll criteria assessment procedures. There are two provisions of this guidance that may affect shortnose sturgeon that were not considered in the previous ESA consultation. The two provisions, the revision to the procedural anomaly in the designated use delineation and the expanded application of deep-water and deep-channel designated uses, will be addressed separately in this evaluation.

The 2003 *Regional Criteria Guidance* defined 5 tidal water habitats as designated uses in the Chesapeake Bay. It also established dissolved oxygen criteria (including 30- day, 7-day and 1 day means and instantaneous minima) to protect various species and life stages within the designated uses. Previous addenda to the *Regional Criteria Guidance* delineated the vertical boundaries for the open-water, deep-water and deep-channel designated uses. More recent information indicates a procedural anomaly which resulted in the application of a long-term average pycnocline to sampling events at times and places where none were found. This, in turn, resulted in the application of the incorrect dissolved oxygen criteria for assessment. EPA finds that this guidance does not modify the dissolved oxygen criteria for the deep water or deep channel as established in the *Regional Criteria Guidance*, but modifies the assessment methodology to clarify this anomaly. It now allows deep water and deep channel designated uses to occur "episodically" for those segments that have been classified as having deep water and deep channel designated uses; when no pyconocline is observed, the open water designated uses applies to the entire water column. This approach eliminates the default use of long term pycnocline average when no pycnocline is observed. EPA finds that this provision of the May 2010 Addendum may affect, but is not likely to adversely affect, shortnose sturgeon as the open water designated use, with its more protective dissolved oxygen criteria, will apply when no pycnocline is observed.

The May 2010 Addendum also reviewed data for several tidal water Chesapeake Bay segments in the mesohaline salinity zone for possible expanded designated use classifications. Based on this review, the South River and the Magothy River segments met the deep-water designated use definition from the *Regional Criteria Guidance*, where a measured pycnocline was present and presented a barrier to oxygen replenishment during the June 1 to September 30 period. Therefore, in the presence of a pycnocline, the deep-water designated use will apply to the South River and the Magothy River, upper pycnocline to lower pycnocline, from June 1 to September 1, inclusive, once Maryland completes a water quality standards regulation revision. Currently, Maryland regulation applies the open water fish and shellfish use year round. EPA finds that this modification to designated uses does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, but the change in designated use does result in the application of the less stringent seasonal deep water criterion in the impacted segments. Although this modification will result in less stringent dissolved oxygen criteria for part of the year, EPA is determining that this designated use modification may affect, but is not likely to adversely affect shortnose sturgeon in these portions of the Chesapeake Bay. EPA's determination is based on the data which indicates that deep water conditions are the existing condition, therefore it is not a change in designated use so much as a refinement to recognize the actual conditions shortnose sturgeon are experiencing, and will continue to experience, in these segments.

JURISDICTIONS' CHESAPEAKE BAY WATER QUALITY STANDARDS REGULATIONS AND PENDING REVISIONS

By early 2006, Delaware, Maryland, Virginia and the District of Columbia had all adopted, and EPA had approved under the CWA Section 303(c), the EPA-published Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll a and the tidal designated uses. In its 2004 water quality standards regulation revision, Delaware adopted the *Regional Criteria Guidance* by reference, and any future published addenda or modifications to the original publication. Maryland, Virginia, and the District of Columbia are each currently in the process of proposing the modification of their respective water quality standards regulations as follows:

District of Columbia

The District of Columbia has adopted the 2003 Chesapeake Bay water quality criteria document into its water quality standards regulations. The District of Columbia has proposed adoption of the EPA-published 2004, 2007, 2008, 2010 Bay criteria addenda by reference. The proposal is pending public review and EPA review and approval.

Maryland

Maryland has adopted most of the EPA-published Chesapeake Bay criteria and designated use documents and subsequent addenda listed in Appendix B by reference into its water quality standards regulations. Maryland has proposed adoption of the EPA published 2010 Bay criteria addendum by reference. The proposal has completed public review, and Maryland is in the process of passing its "Notice of Final Action" to adopt the revisions as proposed (no changes). The revisions will be considered effective for CWA purposes once EPA reviews and approves under CWA Section 303(c).

In addition to adoption of the 2010 Bay criteria addendum by reference, the Maryland revisions also proposed the following amendments to its water quality standards regulations: adopting a 14 percent restoration variance for the lower Chester River segment deep-channel dissolved oxygen criteria application; adopting a site-specific 4 mg/L 30-day mean dissolved oxygen criterion for the upper and middle tidal Pocomoke River segments; applying the deep-water designated use, in the presence of observed pycnoclines, in the South, Severn and Magothy river segments; a 30-acre SAV restoration acreage for the Back River segment; a 1-acre SAV restoration acreage for the upper Chester River segment; and recognizing the middle Pocomoke River segment as an SAV no-grow zone.

Virginia

Virginia has adopted most of the EPA-published Chesapeake Bay criteria and designated use documents and subsequent addenda listed in Table 3-1 by reference into its water quality standards regulation. Virginia has proposed adoption of the EPA-published 2007, 2008, and 2010 Bay criteria addendum by reference. The proposal is pending public review and EPA review and approval.

Biological Evaluation of Jurisdictions' Chesapeake Bay Water Quality Standards Regulations and Pending Revisions

The intent of the ESA consultation that EPA and the Services concluded in 2004 was to consult on the *Regional Criteria Guidance* to ensure a consistent approach to evaluating the effects of the established parameter criteria on species and identifying measures that may be needed to better protect such species. The *Regional Criteria Guidance* consultation provides section 7 coverage for any water quality criteria included in State water quality standards approved by EPA that are identical to or more stringent than that recommended in the *Regional Criteria Guidance*. Separate consultation is not necessary unless a State adopts a standard that is not identical or more stringent than what was covered in the consultation.

EPA approvals of the state actions that adopted the 2003 EPA-published Chesapeake Bay water quality criteria for dissolved oxygen, water clarity and chlorophyll *a* and the tidal designated uses were covered under the consultation concluded in 2004. This evaluation of the effects of the published addenda to the 2003 criteria documents on shortnose sturgeon, and NOAA Fisheries response, is intended to have the same effect as the previous consultation (i.e., separate consultation is not necessary unless a State adopts a standard that is not identical or more stringent than what was covered in the consultation).

The District of Columbia and Virginia's proposed revisions are adopting by reference EPA's criteria addenda. As those addenda are addressed in this evaluation, no further consultation will be necessary once EPA and NOAA Fisheries conclude this consultation.

Maryland's proposed water quality standards revisions are not all addressed in EPA's evaluation of the criteria addendum. As the primary purpose of this evaluation is to address the impacts of dissolved oxygen criteria on shortnose sturgeon, EPA will not evaluate Maryland's revisions to address SAV, as it was concluded in the previous consultation that the SAV criteria would not impact shortnose sturgeon. The revisions to apply the deep-water designated use, in the presence of observed pycnoclines, in the South and Magothy river segments are addressed in the EPA's evaluation in this document of the 2010 Bay criteria addendum. EPA discussed below Maryland's adoption of a 14 percent restoration variance for the lower Chester River segment deep-channel dissolved oxygen criteria application; adoption of a site-specific 4 mg/L 30-day mean dissolved oxygen criterion for the upper and middle tidal Pocomoke River segments; and the application of the deep-water designated use, in the presence of observed pycnoclines, in the Severn river segment.

Maryland has proposed a new dissolved oxygen seasonal (June 1 – September 30) deep-channel refuge subcategory restoration variance no more that 14 percent spatially and temporally (in combination) for the Lower Chester River mesohaline segment of the Chesapeake Bay. The basis for establishing the variance is the limited response of dissolved oxygen concentrations to reduced nutrient loads in the lower Chester River deep-channel, combined with the physical characteristics of the narrow, deep channel in this region that suggests a natural constraint on the re-oxygenation of the lower mixed layer by either deep riverine flows or deep estuarine flows from the adjacent mainstem Bay. EPA finds that our approval of these revisions may affect, but is not likely to adversely affect, shortnose sturgeon in this portion of the Chesapeake Bay. We make this determination because modeling based on almost two decades of historical monitoring data show a consistent pattern of summer severe hypoxic to anoxic conditions, and model simulated improvements in dissolved oxygen concentration did not yield full attainment of dissolved oxygen criteria. This portion is not expected to recover to the point that it meets the dissolved oxygen criteria for the deep-channel as established in the *Regional Criteria Document*, due in great part to the natural constraints discussed above, however, the expected partial improvements will increase the percentage of tolerant habitat for the shortnose sturgeon. Additional information on this finding is included as Appendix B to this document.

Maryland revised the dissolved oxygen criteria for the Upper Pokemoke River tidal fresh and the Maryland portion of the Middle Pokemoke River oligohaline segment of the Chesapeake Bay. The new criterion, a site-specific 30-day mean dissolved oxygen criterion of 4.0 mg/L, reflects the naturally high organic content in the Pokemoke River resulting from the presence of extensive wetland acreage at headwaters and adjacent shoreline. EPA finds that our approval of these revisions will have no effect on shortnose sturgeon, as it reflects the natural condition due to the high organic content. For NOAA Fisheries consideration, based on review of monthly data collected from 1986 through 2009, there were only 5 events when the water column average temperature exceeded 29°C, and the open-water criterion (4.3 mg/L) was violated only one time (i.e., approximately 0.4 % of the data fail to meet the criterion). Additional information on this finding is included as Appendix C to this document.

Maryland has proposed to apply the deep-water designated use, in the presence of observed pycnoclines, in the Severn River segment. As EPA discussed earlier in this document, the May 2010 addendum reviewed data for several tidal water Chesapeake Bay segments in the mesohaline salinity zone for possible expanded designated use classifications. Following publication of the May 2010 addendum, it was determined that the Severn River segment also met the deep-water designated use definition from the *Regional Criteria Guidance*, where a measured pycnocline was present and presented a barrier to oxygen replenishment during the June 1 to September 30 period. Therefore, in the presence of a pycnocline, the deep-water designated use should also apply to the Severn River, upper pycnocline to lower pycnocline, from June 1 to September 1, inclusive, once Maryland completes a water quality standards regulation revision. EPA finds that this modification to designated uses does not modify the dissolved oxygen criteria for the open water, deep water or deep channel as established in the *Regional Criteria Guidance*, but the change in designated use does result in the application of the less stringent seasonal deep water criterion in the impacted segment. Although this modification will result in less stringent dissolved oxygen criteria for part of the year, EPA is determining that this designated use modification may affect, but is not likely to adversely affect shortnose sturgeon in these portions of the Chesapeake Bay. EPA's determination is based on the data which indicates that deep water conditions are the existing condition, therefore it is not a change in designated use so much as a refinement to recognize the actual conditions shortnose sturgeon are experiencing, and will continue to experience, in these segments.

THE CHESAPEAKE BAY TOTAL MAXIMUM DAILY LOAD (TMDL)

Background

EPA's April 2003 biological evaluation included a description of the 1987 and 2000 Chesapeake Bay Agreements. The 2000 Agreement, entitled Chesapeake 2000, included specific action as steps to achieve water quality goals for nutrients and sediment. One specific action was the issuance of the Regional Criteria Guidance.

In 2003, EPA and its watershed partners established nutrient and sediment cap loads on the basis of the Bay water quality model projections of attainment of the then EPA-proposed DO water quality criteria under long-term average hydrologic conditions. Reaching those cap loads was expected to eliminate the summer anoxic conditions in the deep waters of the Bay and the excessive algal blooms throughout the Bay and tidal tributaries.

EPA and its watershed jurisdiction partners agreed to divide up the nutrient cap loads among the major river basins. Those jurisdictions with the highest impact on Bay water quality were assigned the highest nutrient reductions, while jurisdictions without tidal waters received less stringent reductions because they would not realize a direct benefit from the improved water quality conditions in the Bay. Sediment allocations were based on the phosphorus-equivalent allocations to each major river basin by jurisdiction.

Although not original signatories of the Chesapeake 2000 Agreement, New York, Delaware, and West Virginia signed on as partners in implementing the cap loads; thus, all seven Bay jurisdictions were assigned allocations. The final total basinwide cap loads agreed to by the jurisdictions were 175 million pounds for nitrogen and 12.8 million pounds of phosphorus delivered to the tidal waters of the Bay. The basinwide upland sediment cap load was 4.15 million tons.

To implement the cap loads, the seven watershed jurisdictions developed what became known as the Chesapeake Bay Tributary Strategies. The tributary strategies outlined river basin-specific implementation activities to reduce nitrogen, phosphorus, and sediment from point and nonpoint sources sufficient to remove the Chesapeake Bay and its tidal tributaries and embayments from the Bay jurisdictions' respective impaired waters lists. Many of the policies and procedures used in developing the Chesapeake Bay TMDL originated with the development of the 2003 nutrient and sediment cap loads and subsequent development of tributary strategies.

Once the four Bay jurisdictions revised their water quality standards regulations to comply with the Regional Criteria Guidance for the Chesapeake Bay and its tidal tributaries, EPA and the seven jurisdictions reevaluated the nutrient and sediment cap loads in 2007. The 2007 reevaluation found that sufficient progress had not been made toward improving water quality in the Chesapeake Bay to a level that the mainstem Chesapeake Bay and its tidal tributaries were no longer impaired by nutrients and sediment.

On May 12, 2009, President Barack Obama issued the Chesapeake Bay Protection and Restoration Executive Order 13508, which calls for the federal government to lead a renewed effort to restore and protect the Chesapeake Bay and its watershed. Critical among its directives were to establish a Federal Leadership Committee to oversee the development and coordination of reporting, data management and other activities by agencies involved in Bay restoration. Pursuant to the Executive Order, on May 12, 2010, the Federal Leadership Committee—led by the EPA Administrator and secretaries from the Departments of Agriculture, Commerce, Defense, Homeland Security, Interior, Transportation and others—issued its coordinated strategy for restoring the Chesapeake Bay. That strategy sets measurable goals for improving environmental conditions in the Bay for the following: Clean water; Habitat; Fish and wildlife; and Land and public access. Other supporting strategies address citizen stewardship, climate change, science, and implementation and accountability. A key element of the approach for meeting water quality goals is the development of a TMDL for the Chesapeake Bay.

Parallel to the issuance of the Executive Order, the jurisdictions and the federal government committed to implement all necessary measures for restoring water quality in the Bay by 2025 and to meet specific milestones every 2 years. While the Executive Order expresses such a commitment, it does not by itself create additional statutory authority for EPA or other federal agency to directly implement or regulate other entities beyond that authority set forth in existing law. EPA is developing an accountability framework to guide the overall restoration effort and to link it to implementation of the Chesapeake Bay TMDL. The accountability framework, which is discussed in more detail in the TMDL, includes four elements:

- Watershed Implementation Plans (WIPs)
- Two-year milestones to demonstrate restoration progress
- EPA's commitment to track and assess progress
- Federal actions if the watershed jurisdictions fail to develop sufficient WIPs, effectively implement their WIPs, or fulfill their 2-year milestones.

TMDLs and the CWA

Section 303(c) of the 1972 CWA requires states, including the District of Columbia, to establish water quality standards that identify each waterbody's designated uses and the criteria needed to support those uses (including aquatic life uses). Section 303(d) of the CWA requires states, including the District of Columbia, to develop lists of impaired waters that fail to meet water quality standards even after implementing technology-based and other pollution controls. EPA's regulations for implementing CWA section 303(d) are codified in the Water Quality Planning and Management Regulations at 40 CFR Part 130. The law requires that jurisdictions establish priority rankings and develop TMDLs for waters on the lists of impaired waters (40 CFR 130.7).

A TMDL specifies the maximum amount of a pollutant that a waterbody can receive and still meet applicable water quality standards. A mathematical definition of a TMDL is written as the sum of the individual wasteload allocations (WLAs) for point sources, the load allocations (LAs) for nonpoint sources and natural background, and a margin of safety [CWA section 303(d)(1)(C)]:

TMDL = $\Sigma WLA + \Sigma LA + MOS$ where

WLA = wasteload allocation, or the portion of the TMDL allocated to existing and/or future point sources.

LA = load allocation, or the portion of the TMDL attributed to existing and/or future nonpoint sources and natural background.

MOS = margin of safety, or the portion of the TMDL that accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality, such as uncertainty about the relationship between pollutant loads and receiving water quality, which can be provided implicitly by applying conservative analytical assumptions or explicitly by reserving a portion of loading capacity.

The process of calculating and documenting a TMDL involves a number of tasks and—especially for a large, complex, multijurisdictional waterbody with multiple impairments—can require substantial effort and resources. Major tasks involved in the TMDL development process include the following:

- Characterizing the impaired waterbody and its watershed
- Identifying and inventorying the relevant pollutant source sectors
- Applying the appropriate water quality standards
- Calculating the loading capacity using appropriate modeling analyses to link pollutant loads to water quality
- Identifying the required source allocations

TMDLs are primarily informational tools that serve as a link in an implementation chain that includes federally regulated point source controls, state or local plans for point and nonpoint source pollutant reduction, and assessment of the impact of such measures on water quality, all to the end of attaining water quality goals for the nation's waters.[1] Recognizing a TMDL's role as a vital link in the implementation chain, federal regulations require that effluent limits in NPDES permits be consistent with the assumptions and requirements of any available WLA in an approved TMDL.[2] The TMDL by itself does not contain an implementation plan nor does it create self executing authority for EPA to implement the TMDL. In other words, an implementation schedule is not included as part of the TMDL, and EPA's action to establish the TMDL does not create additional legal authority to implement the TMDL plan beyond that contained in the CWA.

Before EPA establishes or approves a TMDL that allocates pollutant loads to both point and nonpoint sources, it determines whether there is *reasonable assurance* that the nonpoint source LAs will, in fact, be achieved and water quality standards will be attained. If the reductions embodied in LAs are not fully achieved, the collective reductions from point and nonpoint sources will not result in attainment of the water quality standards. The CWA does not give EPA authority to regulate nonpoint sources.

EPA's Draft Chesapeake Bay TMDL

On September 24, 2010, EPA issued the draft Chesapeake Bay TMDL. The TMDL will be established for the tidal segments of the Chesapeake Bay and its tidal tributaries and embayments that are impaired for aquatic life uses due to excessive loads of nutrients (nitrogen and phosphorus) and sediment and listed on the four tidal Bay jurisdictions' respective CWA 2008 section 303(d) lists of impaired waters. The Bay TMDL also allocates loadings of nitrogen, phosphorus, and sediment to sources contributing those pollutants in all seven jurisdictions in the Bay watershed—Delaware, the District of Columbia, Maryland, New York, Pennsylvania, Virginia, and West Virginia.

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[1] Pronsolino v. Nastri, 291 F.3d 1123, 1129 (9th Cir. 2002).
[2] 40 CFR 122.44(d)(1)(vii)(B).

The TMDL is designed to ensure that that all pollution control measures to fully restore the Bay and its tidal rivers are in place by 2025, with 60 percent of the actions completed by 2017. It is EPA's intent to have the final TMDL established by December 31, 2010.

For purposes of this consultation only, EPA is treating the establishment of the Chesapekae Bay TMDL as a Federal action, and as such, is subject to review under the ESA. EPA finds that the establishment of the Chesapeake Bay TMDL may affect, but will not adversely affect, shortnose sturgeon in the Bay. EPA is making this finding because the ultimate achievement of water quality standards will create a greater percentage of tolerant habitat for the shortnose sturgeon.

TMDL Implementation

In reviewing EPA's evaluation and finding, NOAA Fisheries must note that there are limits to the scope of EPA's authorities under the CWA to implement the TMDL. Federal regulations at 40 CFR 122.44(d)(1)(vii)(B) require that effluent limits in National Pollutant Discharge Elimination System (NPDES)permits be consistent with "the assumptions and requirements of any available wasteload allocation" in an approved TMDL. The existence of an NPDES regulatory program and the issuance of an NPDES permit provides the reasonable assurance that the wasteload allocations in a TMDL will be achieved. Except for the District of Columbia where EPA issues the NPDES permits, in each of the other jurisdictions, the state is the authorized NPDES permit issuing authority. EPA has discretionary oversight authority regarding the issuance of the state NPDES permit. When EPA establishes or approves a TMDL that allocates pollutant loads to both point and nonpoint sources, as the Chesapeake Bay TMDL does, it must determine whether there is reasonable assurance that the load allocations from nonpoint sources will be achieved and water quality standards will be attained.

The Bay TMDL will be implemented using an accountability framework that includes WIPs, 2-year milestones, EPA's tracking and assessment of restoration progress and, as necessary, specific federal actions if the Bay jurisdictions do not meet their commitments. The accountability framework is being established, in part, to demonstrate that the TMDL is supported by reasonable assurance. The accountability framework is also being established in conjunction with the Bay TMDL pursuant to CWA section 117(g)(1). Section 117(g) of the CWA directs the EPA Administrator to "ensure that management plans are developed and implementation is begun...to achieve and maintain...the nutrient goals of the Chesapeake Bay Agreement for the quantity of nitrogen and phosphorus entering the Chesapeake Bay and its watershed, [and] the water quality requirements necessary to restore living resources in the Chesapeake Bay ecosystem."[3] In addition, Executive Order 13508 directs EPA and other federal agencies to build a new accountability framework that guides local, state, and federal water quality restoration efforts. The accountability framework is designed to help ensure that the Bay's nutrient goals, as embodied in the Chesapeake Bay TMDL, are met. While the accountability framework informs the TMDL, CWA Section 303(d) does not require that EPA approve the framework *per se*, or the jurisdictions' WIPs that constitute part of that framework. This accountability framework also does not create EPA (or other federal agency) authority to directly implement those actions beyond the scope of the CWA or other applicable statutes.

[3] Section 117(g)(1)(A)-(B) of CWA, 33 U.S.C. 1267(g)(1)(A)-(B).

Reasonable assurance for the Chesapeake Bay TMDL is provided by the numerous federal, state and local regulatory and non-regulatory programs identified in the accountability framework that EPA believes will result in the necessary point and nonpoint source controls and pollutant reduction programs. The most prominent program is the CWA's NPDES permit program that regulates point sources throughout the nation. In the Bay, all of the jurisdictions with the exceptions of the District of Columbia, administer the federal NPDES permit program with oversight provided by EPA. Many nonpoint sources are not covered by a similar federal permit program; as a result, financial incentives and other voluntary programs are used to achieve nonpoint source reductions. These federal tools are supplemented by a variety of state regulatory and voluntary programs and other commitments of the federal government set forth in the Executive Order strategy and identified in the accountability framework discussed above.

Beginning in 2012, jurisdictions (including the federal government) are expected to develop two-year milestones to track progress toward reaching the Bay TMDL's goals. In addition, the milestones will demonstrate the effectiveness of the jurisdictions' WIPs by identifying specific near-term pollutant reduction controls and a schedule for implementation (see next section for further description of WIPs). EPA will review these two-year milestones and evaluate whether they are sufficient to achieve necessary pollution reductions and, through the use of a Bay Tracking and Accountability System, determine if milestones are met.

If a jurisdiction's plans are inadequate or its progress is insufficient, EPA can invoke a suite of backstop actions to ensure pollution reductions. These include expanding coverage of NPDES permits to sources that are currently unregulated, increasing oversight of state-issued NPDES permits, requiring additional pollution reductions from point sources such as wastewater treatment plants, increasing federal enforcement and compliance in the watershed, prohibiting new or expanded pollution discharges, redirecting EPA grants, and revising water quality standards to better protect local and downstream waters.

Finally, the cornerstone of the accountability framework is the jurisdictions' development of WIPs, which serve as roadmaps for how and when a jurisdiction plans to meet its pollution allocations under the TMDL. In their draft Phase I WIPs, the jurisdictions were expected to subdivide the Bay TMDL allocations among pollutant sources; evaluate their current legal, regulatory, programmatic and financial tools available to implement the allocations; identify and rectify potential shortfalls in attaining the allocations; describe mechanisms to track and report implementation activities; provide alternative approaches; and outline a schedule for implementation.

SUMMARY AND CONCLUSION

The purpose of this addendum to EPA's 2003 Biological Evaluation of the Chesapeake Bay Regional Criteria Guidance was to evaluate any impacts to shortnose sturgeon resulting from EPA's issuance of a number technical support documents and addenda to the 2003 criteria and EPA's proposed Chesapeake Bay TMDL, specifically due to dissolved oxygen concentrations. Regarding the addenda to the 2003 criteria, for the most part, EPA found that there is no effect on shortnose sturgeon beyond that already consulted upon and concluded in

April 2004. The exception is 2010 *Technical Support for Criteria Assessment Protocols Addendum* (EPA 903-R-10-002). EPA found that two provisions, the revision to the procedural anomaly in the designated use delineation and the expanded application of deep-water and deep-channel designated uses, may affect, but are not likely to adversely affect, shortnose sturgeon.

This Biological Evaluation also reviewed revisions to state water quality standards based upon the 2003 criteria addenda. The District of Columbia, Delaware and Virginia are adopting by reference EPA's 2003 criteria addenda, and as those documents are reviewed in this document, no further evaluation is necessary. Maryland is making a number of revisions which EPA believed need to be evaluated separately from the 2003 criteria addenda. Maryland has proposed to expand the application of the deep-water and deep-channel designated use for the Severn River, Maryland has also proposed a new dissolved oxygen seasonal (June 1 – September 30) deep-channel refuge subcategory restoration variance for the Lower Chester River mesohaline segment of the Chesapeake Bay. In both of these cases, EPA has found that our approval may affect, but are not likely to adversely affect, shortnose sturgeon. Maryland is also proposing a site-specific dissolved oxygen criterion for the Upper Pokemoke River tidal fresh and the Maryland portion of the Middle Pokemoke River oligohaline segment based upon natural conditions. EPA found that our approval of this revision will have no effect on shortnose sturgeon, as it reflects the natural condition due to the high organic content.

Finally, EPA found that its establishment of the Chesapeake Bay TMDL may affect, but will not adversely affect, shortnose sturgeon in the Bay. EPA is made this finding because the ultimate achievement of water quality standards will create a greater percentage of tolerant habitat for the shortnose sturgeon.

Based on the evaluation conducted in this document, it is EPA's conclusion that several provisions may affect, but are not likely to adversely affect, the continued existence of shortnose sturgeon in the Chesapeake Bay. Through continued refinements to the criteria and assessment methodologies, and implementation of the TMDL, it is EPA's belief that these actions will directly lead to increased levels of suitable habitat for shortnose sturgeon.

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http://www.dcregs.dc.gov/Gateway/ChapterHome.aspx?ChapterNumber=21-11

Virginia Water Quality Standards. State Water Control Board. Available on-line at:
http://www.deq.state.va.us/wqs/documents/WQS_eff_1FEB2010.pdf

State of Delaware Surface Water Quality Standards. Department of Natural Resources and Environmental Control. Available on-line at:
http://www.dnrec.state.de.us/DNREC2000/Divisions/Water/WaterQuality/WQStandard.pdf

Appendix A:

Chesapeake Bay water quality criteria and designated use related documentation and addenda Document title	Month/year published	Document content and description
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries. EPA 903-R-03-002. [USEPA 2003a]	April 2003	Original Chesapeake Bay water quality criteria document.
Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability. EPA 903-R-03-004. [USEPA 2003c]	October 2003	Original Chesapeake Bay tidal waters designated uses document.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries—2004 Addendum. EPA 903-R-03-002. [USEPA 2004a]	October 2004	Addresses endangered species protection, assessment of DO criteria, derivation of site-specific DO criteria, pycnocline boundary delineation methodology and updated water clarity criteria/SAV restoration acreage assessment procedures.
Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability—2004 Addendum. EPA 903-R-04-006. [USEPA 2004e]	October 2004	Addresses refinements to Bay tidal waters designated use boundaries, segmentation boundaries, Potomac River jurisdictional boundaries, and documents SAV no-grow zones, restoration goal, and shallow-water acreages.

Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983–2003. EPA 903-R-04-008. CBP/TRS 268-04. [USEPA 2004b]	October 2004	Details documentation on the history of the segmentation schemes and coordinates, georeferences and narrative descriptions of the 2003 segmentation scheme.
Chesapeake Bay Program Analytical Segmentation Scheme: Revisions, Decisions and Rationales 1983–2003: 2005 Addendum. EPA 903-R-05-004. CBP/TRS 278-06. [USEPA 2005]	December 2005	Addresses methods used to subdivide the segments by jurisdiction and the coordinates, georeferences and narrative descriptions for those subdivided segments.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a *for the Chesapeake Bay and Its Tidal Tributaries—2007 Addendum.* EPA 903-R-07-003. CBP/TRS 285-07. [USEPA 2007a]	July 2007	Addresses refinements to the Bay water quality DO, water clarity/SAV and chlorophyll *a* criteria assessment methodologies and documents the framework for Bay tidal waters 303(d) list decision making.
Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a *for the Chesapeake Bay and Its Tidal Tributaries—2007 Chlorophyll Criteria Addendum.* EPA 903-R-07-005. CBP/TRS 288/07. [USEPA 2007b]	November 2007	Publishes a set of numerical chlorophyll *a* criteria for Chesapeake Bay and the supporting criteria assessment procedures.

Appendix B

Chester River Deep-Channel Dissolved Oxygen Criterion Persistent Non-Attainment: Diagnostic Findings

U.S. EPA Chesapeake Bay Program Office
Annapolis, Maryland

27 August, 2010

During the course of developing the Chesapeake Bay TMDL, numerous nutrient load reduction simulations were conducted to determine the effect of pollutant reductions on attainment of established Maryland, Virginia, Delaware and District of Columbia's Chesapeake Bay water quality standards (WQS) for dissolved oxygen (DO).

Chesapeake Bay water quality/sediment transport model-simulated nutrient load reductions resulted in higher simulated DO concentrations, allowing identification of load reductions sufficient for attaining the jurisdictions' WQS, in the majority of deep-water and deep-channel regions of the Chesapeake Bay and its tidal tributaries. The deep-channel of the lower tidal Chester River segment was a notable exception.

Historical monitoring data show a consistent pattern of summer severe hypoxic to anoxic (<0.2 mg/L dissolved oxygen concentrations) conditions in the deep-channel region of the lower Chester River, in the vicinity of monitoring station ET4.2 (Figure 1).

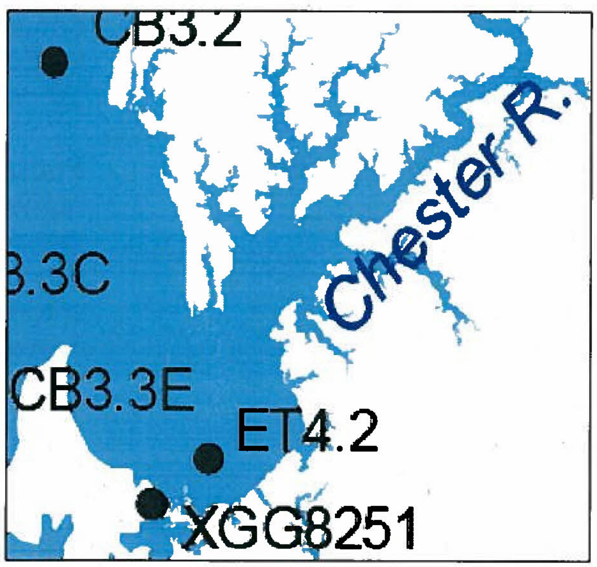

Figure 1. The Lower Chester River is characterized by Maryland's Chesapeake Bay water quality monitoring program station ET4.2.

In summer months, observed DO concentrations at monitoring station ET4.2 consistently fell below 1.0 mg/L, the instantaneous minimum criterion for the deep-channel designated use (Figure 2).

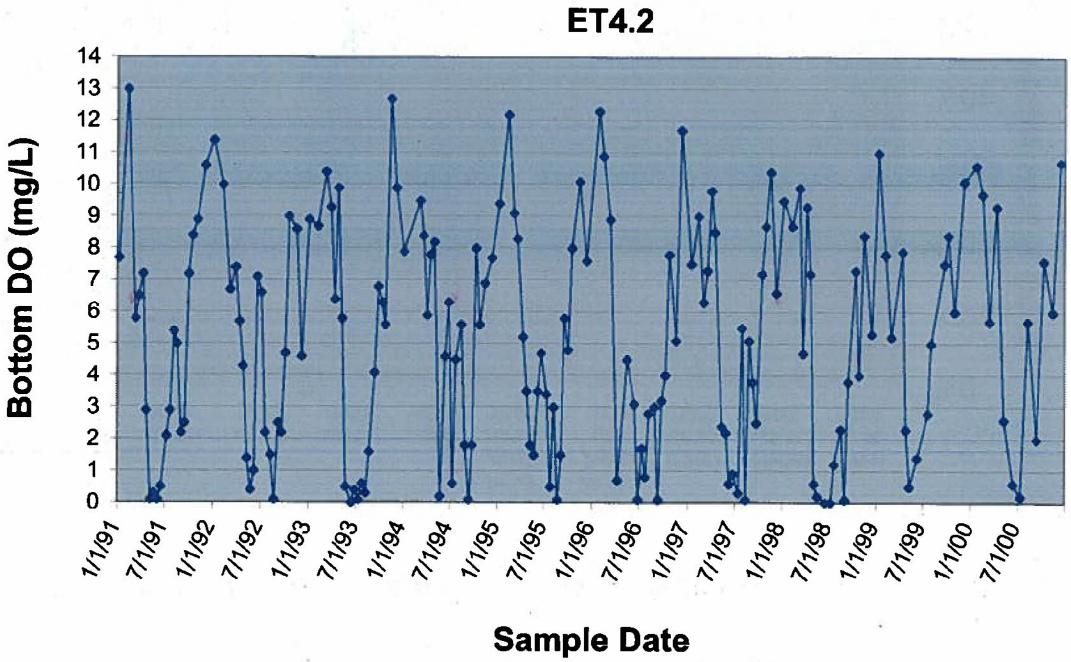

Figure 2. "Bottom" depth dissolved oxygen (DO) concentrations measured at monitoring station ET4.2 from January 1991 – December 2000. Source: http://www.chesapeakebay.net

At model-simulated nutrient load reductions that led to attainment of deep-channel dissolved oxygen criteria in all other deep-channel regions of the Chesapeake Bay and tidal tributaries (e.g. segments in the Chesapeake Bay mainstem, lower Potomac River, lower Rappahannock River, and Patapsco River), model simulated improvements in dissolved oxygen concentration in the lower Chester River's deep-channel did not yield full attainment of dissolved oxygen criteria. Whereas other deep-channel regions showed attainment of the deep channel dissolved oxygen criterion at or before the 190 TN, 12.7TP loading scenario, the lower Chester River's deep-channel non-attainment remained at a plateau of approximately 10-14% under loading scenarios ranging from 191 TN, 14.4 TP down to approximately 170 TN, 11.3 TP. Full attainment of the applicable dissolved oxygen criterion was not achieved for this deep-channel region until the highly theoretical and unattainable "All Forest" scenario, for which it is assumed that all land in the Chesapeake Bay watershed reverts to a forested condition (Figure 3).

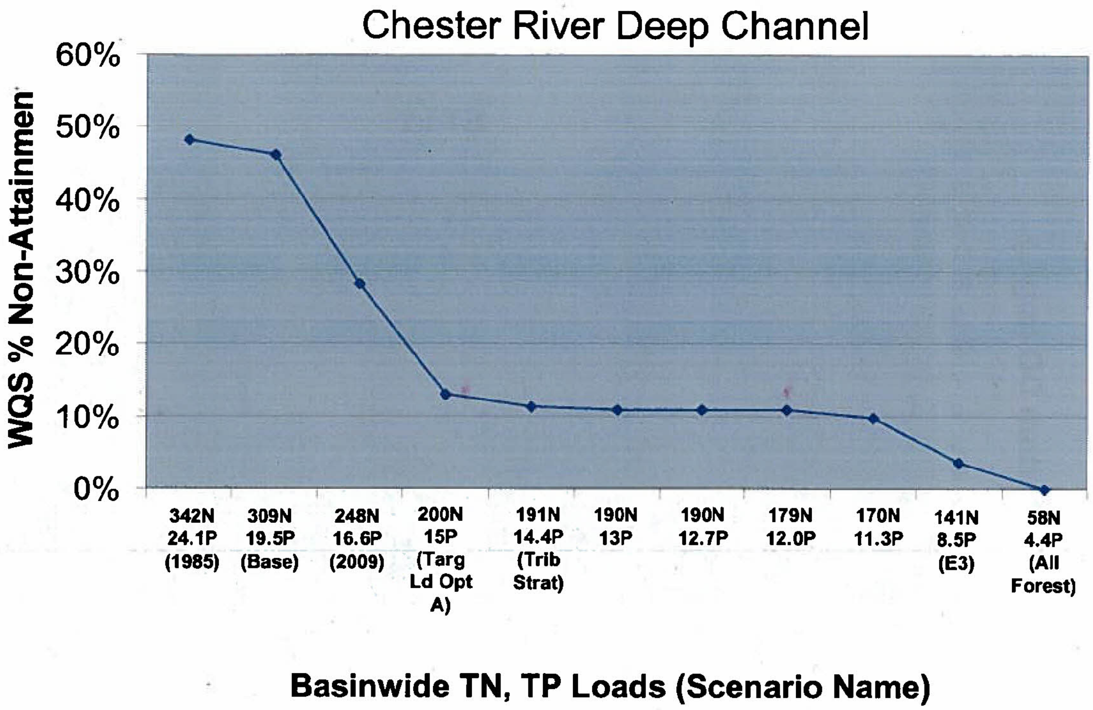

Figure 3. Percent non-attainment of lower Chester River deep-channel dissolved oxygen criterion with decreasing total nitrogen (TN) and total phosphorus (TP) loads.

In-depth examination of the Bay water quality model scenario outputs showed stepwise increases in DO concentrations with incremental nutrient load reductions in the lower Chester River (CHSMH) segment at surface and mid-depths, and consistent simulation of bottom water anoxia. However, the response of DO concentrations at lower-depths in the water column - and particularly at the bottom of the water column - appeared to be constrained to a degree that prevented full attainment of the 1.0 mg/L deep-channel dissolved oxygen criterion under model simulated nutrient load reductions that yield full attainment in all other deep-channel regions of the Chesapeake Bay and its tidal tributaries (Figure 4).

Cbseg	"91 -'00 Base Scenario 309TN, 19.5TP, 8950TSS '93-'95 DO Deep Channel	2009 Scenario 248TN, 16.6TP, 8110TSS '93-'95 DO Deep Channel	Target Load Option A 200TN, 15TP, 6390TSS '93-'95 DO Deep Channel	Trib Stategy 191TN 14.4TP, 6462 TSS '93-'95 DO Deep Channel	190 Loading Scenario 190TN 12.6TP, 6030TSS '93-'95 DO Deep Channel	179 Loading Scenario 179TN 12.0TP, 5510TSS '93-'95 DO Deep Channel	170 Loading Scenario 170TN 11.3TP, 5650TSS '93-'95 DO Deep Channel	E3 2010 Scenario 141TN 8.6TP, 5060TSS '93-'95 DO Deep Channel	All Forest Scenario '93-'95 DO Deep Channel
CB3MH	14%	6%	0%	0%	0%	0%	0%	0%	0%
CB4MH	46%	22%	4%	2%	2%	0%	0%	0%	0%
CB5MH	22%	2%	0%	0%	0%	0%	0%	0%	0%
CHSMH	38%	27%	14%	14%	14%	14%	9%	4%	0%
EASMH	26%	13%	4%	2%	1%	0%	0%	0%	0%
MD5MH	24%	4%	0%	0%	0%	0%	0%	0%	0%
PATMH	27%	21%	0%	0%	0%	0%	0%	0%	0%
POMMH	20%	0%	0%	0%	0%	0%	0%	0%	0%
POTMH	20%	0%	0%	0%	0%	0%	0%	0%	0%
POVMH	0%	0%	0%	0%	0%	0%	0%	0%	0%
RPPMH	31%	0%	0%	0%	0%	0%	0%	0%	0%
VA5MH	11%	0%	0%	0%	0%	0%	0%	0%	0%

Figure 4. Dissolved oxygen percent non-attainment for the deep-channel designated use segments in the Chesapeake Bay and its tidal tributaries.

It is postulated that the bathymetry of the lower Chester River provides a physical barrier to complete re-oxygenation of the deepest region of the lower Chester River even under extremely high nutrient reductions. A narrow deep channel transects the center of the lower Chester River, and exchange of oxygenated deep waters between the mainstem Chesapeake Bay and this deep hole may be restricted by the wider, shallower shoal region at the mouth of the river (Figures 5 and 6).

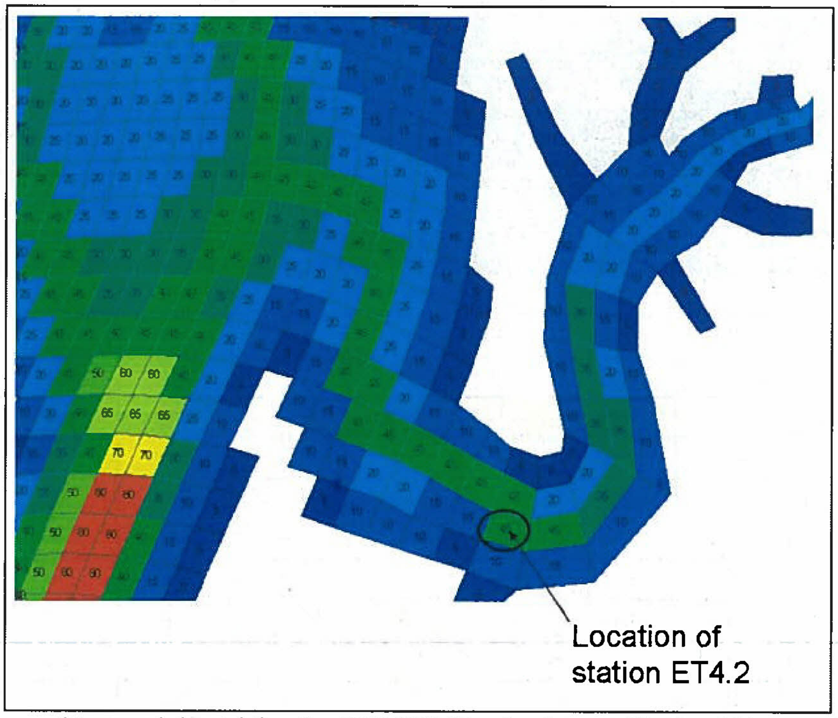

Figure 5. water quality model grid for the WQSTM in the lower Chester River, with total depth for each cell labeled (in feet). The cell corresponding to the location of monitoring station ET4.2 is outlined in black. Source: EPA Chesapeake Bay Program.

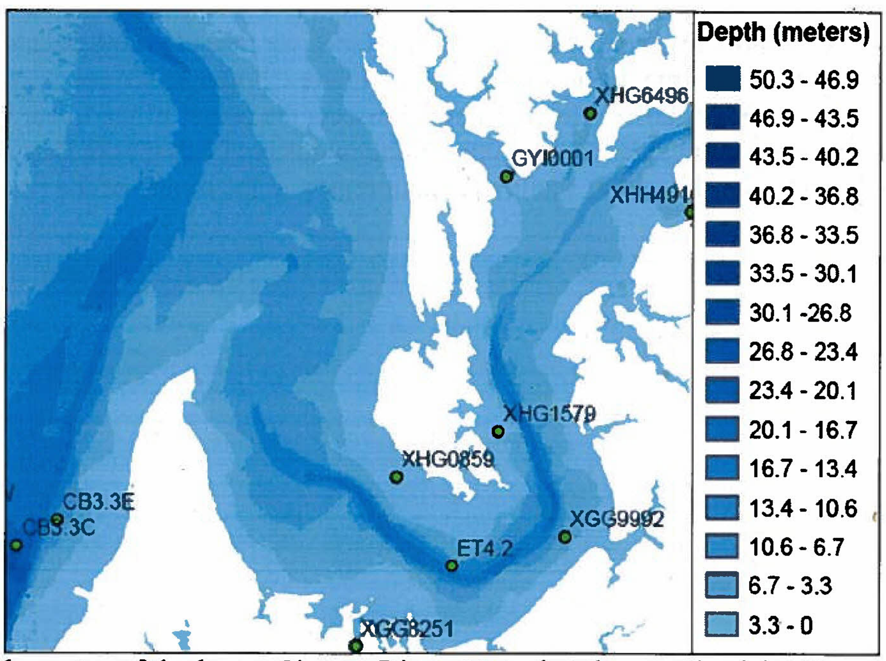

Figure 6. Bathymetry of the lower Chester River. Note that the mouth of the Chester River is shallower than the vicinity of fixed monitoring station ET4.2. Source: EPA Chesapeake Bay Program.

The limited response of DO concentrations to reduced nutrient loads (e.g., 30-140 million pounds basinwide) in the lower Chester River deep-channel, combined with the physical characteristics of the narrow, deep channel in this region, suggest a natural constraint on the re-oxygenation of the lower mixed layer by either deep riverine flows or deep estuarine flows from the adjacent mainstem Bay. Therefore, given the currently available information, EPA recommends a variance of 14% to account for persistent WQS non-attainment in the CHSMH Deep Channel designated use at the basinwide loads of 190TN, 12.7 TP. The selection of a 14% variance is based on the observation that dropping the basinwide loads by up to 20 million pounds per year yields relatively little change in the non-attainment percentage, which ranges only from 10-14% over this reduction level.

Appendix C

Justification for Application of a Site-Specific Dissolved Oxygen Criterion to the Upper Tidal Fresh and Middle Oligohaline Pocomoke River Segments Due to Natural Conditions

Introduction

The Pocomoke River, which forms the eastern border between Wicomico and Worcester Counties in Maryland, runs approximately 73 miles from its headwaters in Sussex County, Delaware to its mouth at Pocomoke Sound on the Chesapeake Bay. Nearly 14 percent of land in the Pocomoke River drainage is wetlands; forest lands cover nearly 48 percent of the watershed. The Great Cypress Swamp, which is located in southern Sussex County, is the origin of the Pocomoke River and the source of much of the organic material that gives the river its characteristic dark color. In addition to giving the Pocomoke River its dark hue, the organic matter generated by the Great Cypress Swamp and other non-tidal and tidal wetlands along the length of the Pocomoke River and its tributaries generate high rates of respiration, which can lead to significant natural reductions in dissolved oxygen concentrations. Together, the Great Cypress swamp and the tidal and non-tidal wetlands of the Pocomoke drainage basin result in a system with the highest dissolved organic carbon concentrations of any Maryland tidal fresh tributary.

The tidal Pocomoke River is classified as "open-water" which includes those waters beyond the shoreline and shallow waters of the Chesapeake Bay and tidal tributaries (U.S. EPA, 2003). Based on requirements promulgated under the Clean Water Act, tidal waters designated as open waters of the State of Maryland are required to meet the dissolved oxygen criteria described in the State of Maryland Code of Regulations - COMAR 26.08.02.03-3(C)(8)(d)(i), COMAR 26.08.02.03-3(C)(8)(d)(v).

The graphical and statistical analyses that follow provide the basis for a site-specific 30-day mean dissolved oxygen criterion of 4.0 mg/L for the tidal fresh and oligohaline segments of the tidal Pocomoke River based on the presence of naturally occurring low dissolved oxygen that results from the presence of high concentrations of organic matter associated with large areas of headwater and fringing wetlands. These findings and the proposed site-specific dissolved oxygen criterion are fully consistent with EPA's amended Chesapeake Bay water quality criteria guidance published in 2004 (U.S. EPA, 2004). The data used in this report were obtained from the Chesapeake Information Management System (CIMS) data base, which is maintained by the U.S. Environmental Protection Agency Chesapeake Bay Program. The data are available to the public from the Chesapeake Bay Program web site: (http://www.chesapeakebay.net). Data were analyzed and figures were prepared using Statistical Analysis System (SAS®) software. All tables and figures are presented at the end of this report.

Water Quality Conditions

The water quality conditions that are described below and appear in Table 1 were based on summer (June through September) data for 2000 through 2002. These summers were found to have "moderate" flow conditions on a scale that ranges from record dry to record wet. Moderate flow conditions represent the middle third of the distribution of flows (greater than or equal to the 33rd percentile and less than the 66th percentile) for the Pocomoke River. The distribution of flows was based on a benchmark data set that included data for the 1975 through 1994 time period. Flow data used in the assignment of flow conditions for this investigation were obtained from the U.S. Geological Survey web site USGS Surface-Water Daily Data for the Nation: (http://waterdata.usgs.gov/nwis/dv?referred_module=sw). The data were from Pocomoke River gage number 01485000, which is located near Willards, MD, for the 1 January 1975 through 20 June 2010 time period. Flow characteristics were assessed using methods developed for the Chesapeake Bay Program (Olson, 2003).

The summary statistics presented in Table 1 were compared to similar statistics presented in Table VI-2 of *Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and its Tributaries – 2004 Addendum* (U.S. EPA, 2004). Chapter VI of the 2004 Bay criteria addendum document provides guidance for developing site specific dissolved oxygen criteria in naturally low dissolved oxygen concentration systems that are influenced by tidal wetlands. The document focuses on the tidal Mattaponi and Pamunkey rivers, which are described as having "naturally lower ambient dissolved oxygen concentrations."[4]

As shown in Table 1, the summer mean 2000 through 2002 surface and bottom dissolved oxygen concentrations for upper tidal fresh river segment POCTF are 4.7 mg/L and 4.6 mg/L, respectively. These values are very close to the surface and bottom dissolved oxygen concentrations reported for the tidal fresh segments of the Mattaponi (MPNTF) (5.6 mg/L for surface and bottom) and Pamunkey (PMKTF) (5.3 mg/L surface and 5.5 mg/L bottom) rivers (U.S. EPA, 2004).

The summer surface 2000-2002 mean chlorophyll-a concentration at POCTF (7.9 μg/L) is 2 μg/L larger than the concentration reported for MPNTF (5.9 μg/L) and 1.7 μg/L larger than the concentration reported for PMKTF (6.2 μg/L). The slightly larger mean concentration at POCTF is the result of one extreme observation (24.4 μg/L) that had an undue influence on the calculation of the mean. The mean summer surface 2000-2002 chlorophyll-a concentration at POCTF without that observation is 6.2 μg/L. Median values are more robust to outliers than means and thus are a more representative measure of central tendency in skewed data. The summer surface 2000-2002 median chlorophyll-a concentration at POCTF (5.98 μg/L) is comparable to those at MPNTF (5.14 μg/L) and PMKTF (5.86 μg/L). The data for all three segments are compared graphically using notched box and whisker plots in Figure 1. Notched box and whisker plots show the range in concentrations, the inter-quartile range, the median, and the mean (+ sign) of the distribution, the endpoint of the notches show the median plus and minus $1.58*(\text{inter-quartile range}/\sqrt{n})$. The medians of notched box-and-whisker plots are significantly different at the 0.05 level if the notches do not overlap. The notches in Figure 1 do overlap, so the median concentrations of chlorophyll-a are not significantly different.

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[4] In 2005, Virginia used the 2004 EPA published Bay criteria addendum (U.S. EPA, 2004) as the basis for promulgating 30-day mean 4 mg/L site-specific dissolved oxygen criterion for the tidal Mattaponi and Pamunkey River segments within the Commonwealth's water quality standards regulations (Code of Virginia 9 § 62.1-44.15 3a; VAC 25-260).

Similarities were also found among these systems for total nitrogen and total phosphorus concentrations (U.S. EPA, 2004).

Dissolved Oxygen Deficit

The dissolved oxygen deficit was calculated as the predicted saturation concentration minus the ambient concentration. Dissolved oxygen saturation concentration is a theoretical value that is calculated using ambient salinity and temperature (Weiss, 1970). The dissolved oxygen deficit provides an indication of the amount of oxygen being consumed in a particular system, but does not indicate whether the consumption rate is dominated by a geochemical or a biological process.

Summer POCTF surface and bottom dissolved oxygen concentrations and dissolved oxygen saturation concentrations for the water quality monitoring program data record are presented in Figures 2 and 3, respectively. With the exception of one datum, dissolved oxygen saturation concentrations exceed ambient concentrations.

Mean dissolved oxygen deficits were calculated for POCTF for surface (3.3 mg/L) and bottom (3.4 mg/L) using June through September data for 2000 through 2002. These values are slightly larger than those reported for MPNTF (2.4 mg/L for surface and bottom) and PMKTF (2.5 mg/L for surface and 2.6 mg/L for bottom) for the same time period (dry flow conditions) (U.S. EPA, 2004). The dissolved oxygen deficits for MPNTF and PMKTF are described as being "among the highest observed in the Chesapeake Bay's tidal tributaries" (U.S. EPA, 2004).

The dissolved oxygen deficits for the moderate flow condition summers of 2000 through 2002 are similar to those observed over the 1986 through 2009 data record, which includes a variety of flow regimes, for surface (Figure 4) and bottom (Figure 5). If the dissolved oxygen deficits for POCTF were the result of external non-point source nutrient loads they should be related to flow, because high flows would result in higher nutrient loads to the system and higher dissolved oxygen deficits. The opposite would be expected during periods of low flow, i.e., low flows would result in lower non-point source nutrient loads and therefore lower dissolved oxygen deficits. The null hypothesis that dissolved oxygen deficits are not related to flow and by extension not to external non-point source nutrient loads, was tested using a general linear model that used dissolved oxygen deficit as the dependent variable and flow and month (to account for seasonality) as explanatory variables. Although the overall model was significant ($p<0.0001$), the significance level for the model was the result of month ($p<0.0001$) and not flow ($p=0.3388$). This indicates that dissolved oxygen deficits are highly seasonal, though not significantly related to flow (Figure 6) and that the observed dissolved oxygen deficits are not related to external nutrient loads. Based on this analysis it seems reasonable to infer that the large dissolved oxygen deficits observed in POCTF are a function of internal processes.

Dissolved Oxygen/Water Temperature Relationships

Another feature of black-water systems, where respiration is dominated by biological and geochemical processes, is a relationship between dissolved oxygen concentration (and dissolved oxygen deficit) and water temperature. Figure 7 shows the dissolved oxygen concentration and dissolved oxygen deficit for POCTF plotted against water temperature using surface data from the period of record. A LOESS curve was fitted to the dissolved oxygen data using water temperature as an independent (explanatory) variable to better illustrate the functional relationship. Figure 7 shows dissolved oxygen concentrations decreasing as water temperature increases due to decreasing dissolved oxygen saturation concentrations and increased respiration from biological sources. The pattern in Figure 7 for segment POCTF is similar to that of MPNTF and PMKTF (U.S. EPA, 2004), which is described as being "evidence of the lack of a strong influence of planktonic algal photosynthesis on dissolved oxygen concentrations...." If algal photosynthesis were influencing dissolved oxygen concentrations in POCTF, one would expect to see an upturn in the daytime, surface dissolved oxygen concentrations at higher water temperatures as opposed to a flattening of the curve. As stated above, summer surface median chlorophyll-a concentrations for segment POCTF (5.98 μ/L) are similar to MPNTF (5.14 μ/L) and PMKTF (5.86 μ/L).

Low Variability in Dissolved Oxygen Concentrations

If the hypothesis that low dissolved oxygen in segment POCTF is a natural condition resulting from its status as a wetland dominated system is correct, dissolved oxygen levels should be relatively consistent between night and day and between surface and bottom layers. Evidence which supports that hypothesis is provided in Table 2. The Maryland Department of Natural Resources (DNR) has measured surface and bottom dissolved oxygen concentrations on a monthly basis at water quality monitoring station ET10.1 in POCTF from 1986 to the present. These samples are collected at a depth of 0.5 meters during the daylight hours when photosynthesis activity by phytoplankton and concentrations of waste oxygen should be at their highest levels.

Between 1998 and 2002 DNR deployed in-situ continuous monitoring devices at three locations on the tidal Pocomoke River at Rehobeth, Cedar Hall Wharf, and Shelltown. The location closest to the POCTF segment was the Rehobeth station, in the upper portion of the POCOH segment, approximately 1 mile down-river from the established boundary with the tidal fresh POCTF segment. Continuous monitors are programmed to take readings for dissolved oxygen and other field parameters every 15 minutes, 24 hours a day. The meter at the Rehobeth station was suspended from a surface float that was configured to position the probe sensors at a consistent depth of one meter below the water surface.

For the comparisons in Table 2, the mean and other statistics of the 1986 through 2009 daytime data at water quality monitoring station ET10.1 were calculated for May through July for surface and bottom layers and compared to the 2002 continuous monitoring data at Rehobeth for day (6:00 A.M through 5:59 P.M) and night (6:00 P.M. through 5:59 A.M.) periods. The low standard deviations and small range in concentrations as measured by the difference between the 5^{th} and 95^{th} percentiles for the long-term data indicate low variability within those months. The dissolved oxygen concentrations for surface and bottom within a month are identical (May and June) or almost identical (July). If the system were dominated by phytoplankton one would expect to see larger differences due to seasonal algal production and differences between surface and bottom dissolved oxygen concentrations due to differences in light availability.

There is also good agreement between the long-term data and the 2002 continuous monitoring data from the Rehobeth station and no difference between the day and night mean dissolved oxygen concentrations for the continuous monitoring data, which further suggests POCTF is not an algal-dominated system. These lines of evidence suggest that low ambient dissolved oxygen concentrations in the POCTF and POCOH segments are largely influenced by extensive natural wetland systems as opposed to phytoplankton populations, findings fully consistent with those reported by U.S. EPA (2004).

Shortnose sturgeon

The State of Maryland has adopted a dissolved oxygen water quality criterion for the protection of shortnose sturgeon (*Acipenser brevirostrum*) under the open-water fish and shellfish subcategory, which states "For protection of the endangered shortnose sturgeon, (dissolved oxygen shall be) greater than or equal to 4.3 milligrams/liter as an instantaneous minimum at water column temperatures greater than 29°C (77°F)" COMAR 26.08.02.03-3(C)(8)(d)(v). The State of Maryland does not currently collect the necessary data to calculate an instantaneous minimum water column dissolved oxygen concentration; however, DNR does measure on a monthly basis dissolved oxygen and water temperature at a number of water column depths at ET10.1 through the Department's ambient water quality monitoring program.

The nominal depth at ET10.1 is 5 meters and physical parameters such as dissolved oxygen and water temperature are generally measured at the surface, one meter off the bottom, and at 1 meter intervals between surface and bottom. The actual number of water column measurements on any particular date does vary depending on tide state and occasional equipment problems. As a result, it is possible to calculate a water column average temperature and dissolved oxygen concentration. The water temperatures and dissolved oxygen concentrations presented in Figure 8 were calculated by averaging the data by sample date over the sample depths that were measured during each cruise. On average, six discrete depths were used in the water column calculations; the number of depths for the entire data record ranged from one to a maximum of nine. As shown in Figure 8, the water column average temperature exceeds 29°C only five times over the period of record. Of those five events, there is only one case where the data indicates a violation occurred such that both the temperature exceeded 29°C and the dissolved oxygen concentration was less than 4.3 mg/L. Thus, based on monthly data collected from 1986 through 2009 it appears that the open-water criterion for the protection of the endangered shortnose sturgeon was violated one time (~0.4 percent of the data fail to meet the criterion).

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Table 1. Summer (June through September) averaged water quality conditions in the Pocomoke tidal fresh (POCTF) segment for 2000 to 2002, moderate flow conditions summers.

CBP Segment	Water Column Layer	Water Column Depth (meters)	Salinity (ppt)	Temperature °C	Dissolved Oxygen Conc. (mg/L)	Dissolved Oxygen Deficit (mg/L)	Chlorophyll-*a* Conc. µg/L	TSS Conc. (mg/L)	TN Conc. (mg/L)	TP Conc. (mg/L)
POCTF	S	0.5	0.7	26.1	4.7	3.3	7.9	12.9	1.64	0.120
POCTF	B	4.9	0.7	26.0	4.6	3.4	7.7	25.7	1.60	0.141

Table 2. Dissolved oxygen concentrations (mg/L) for 1986 through 2009 for ET10.1 in POCTF and the 2002 continuous monitoring dissolved oxygen measurements collected at the Rehobeth station in POCOH.

CBP Segment	Station	Depth (meters)	Month	Year	Period	Mean	Standard deviation	5th percentile	Median	95th percentile
POCTF	ET10.1	0.5	May	NA	Day	5.8	0.9	4.1	5.7	7.3
POCTF	ET10.1	4.9	May	NA	Day	5.8	0.9	4.0	5.7	7.4
POCTF	ET10.1	0.5	June	NA	Day	4.6	1.1	3.4	4.5	6.7
POCTF	ET10.1	5.1	June	NA	Day	4.6	1.1	3.0	4.6	6.6
POCTF	ET10.1	0.5	July	NA	Day	4.4	1.0	3.0	4.5	5.8
POCTF	ET10.1	4.7	July	NA	Day	4.3	0.9	3.2	4.4	5.7
POCOH	Rehobeth	1.0	May	2002	Day	6.0	0.5	5.0	6.1	6.7
POCOH	Rehobeth	1.0	May	2002	Night	6.0	0.4	5.1	6.2	6.4
POCOH	Rehobeth	1.0	June	2002	Day	5.4	0.8	4.0	5.4	6.6
POCOH	Rehobeth	1.0	June	2002	Night	5.4	0.7	4.0	5.5	6.4
POCOH	Rehobeth	1.0	July	2002	Day	5.6	1.0	4.2	5.5	7.5
POCOH	Rehobeth	1.0	July	2002	Night	5.6	0.8	4.3	5.6	7.0

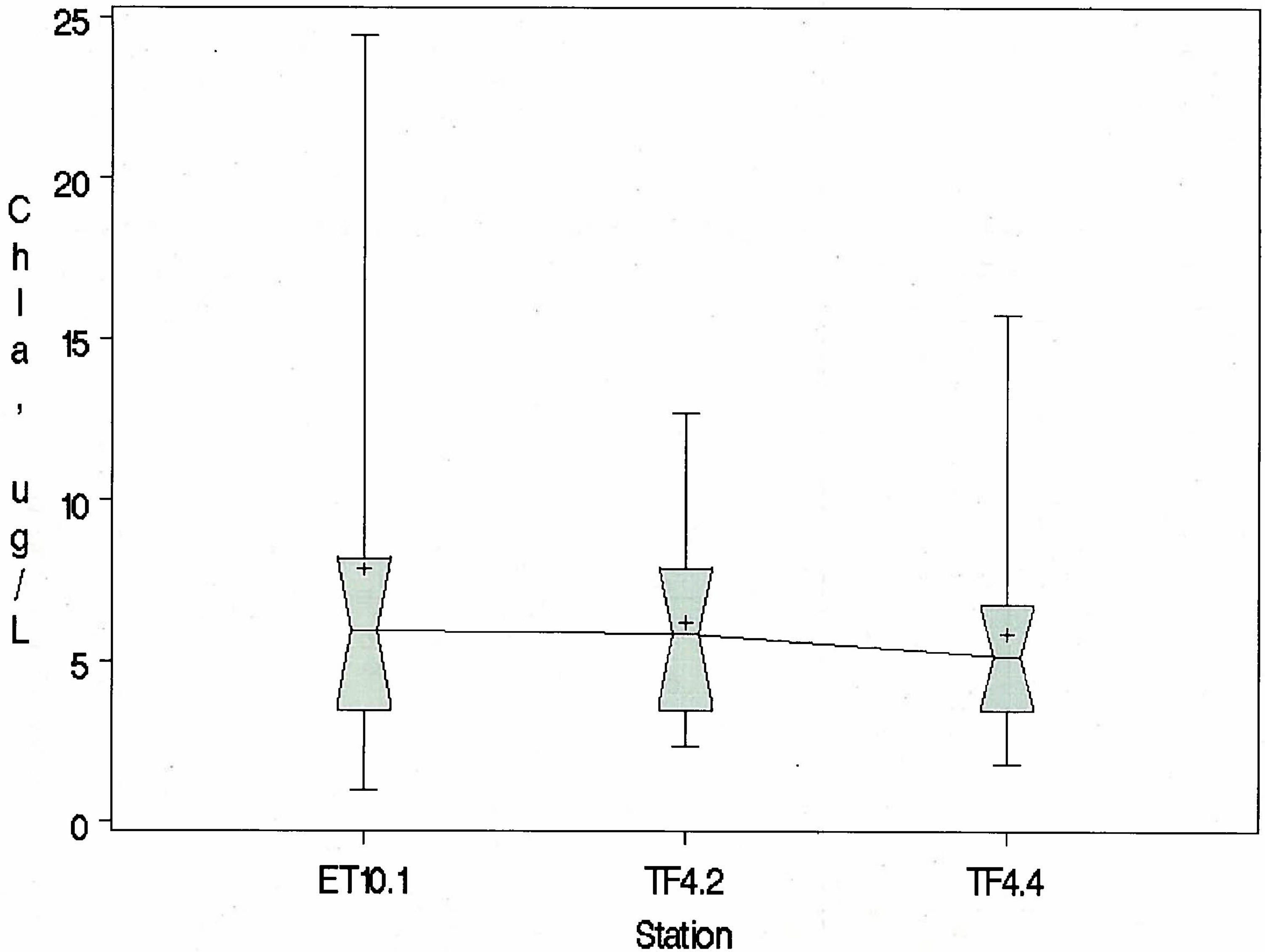

Figure 1. Notched box and whisker plots showing the distribution of chlorophyll for June through September 2000 through 2002 for ET10.1 (POCTF), TF4.2 (PMKTF), and TF4.4 (MPNTF).

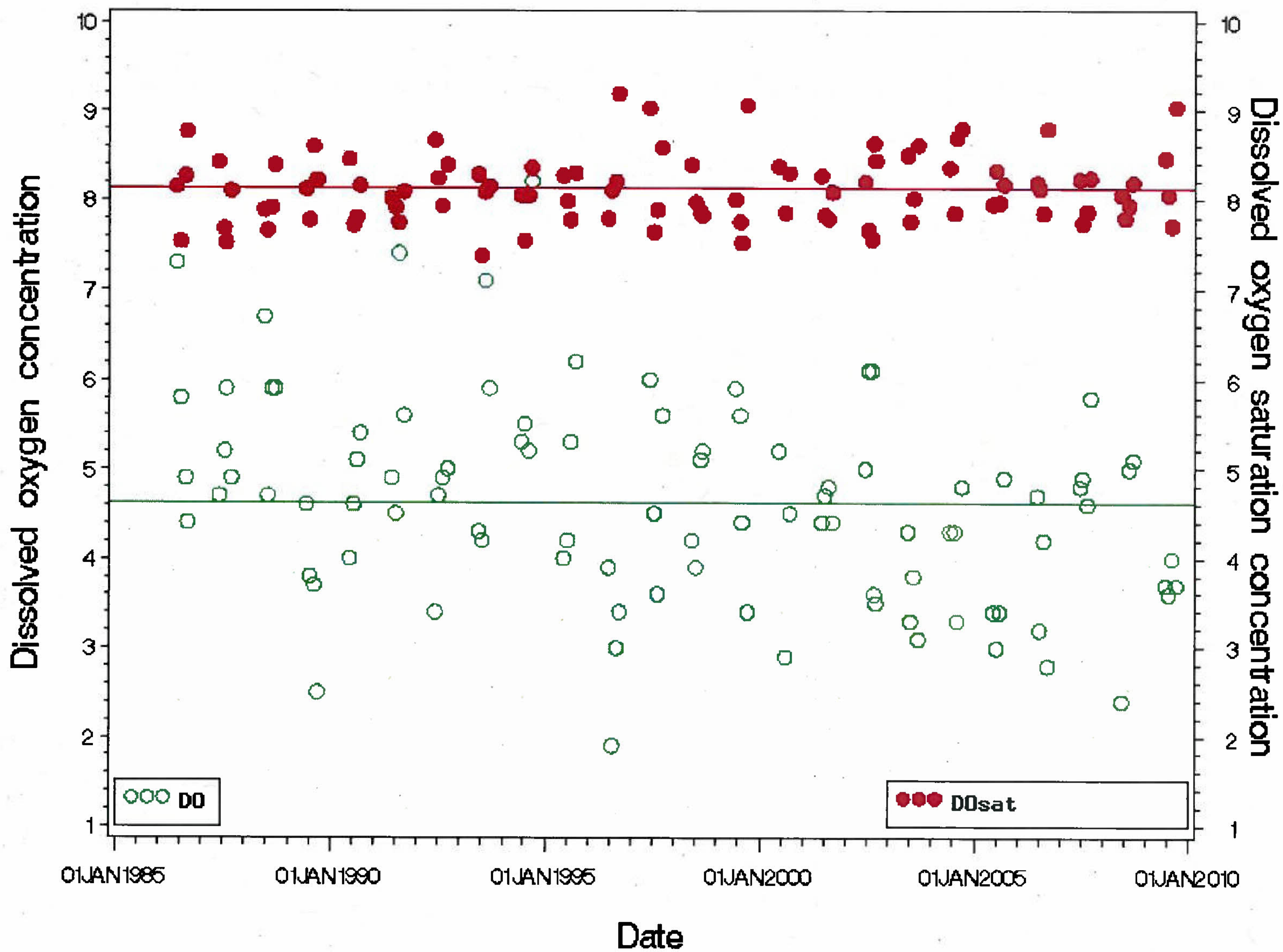

Figure 2. Station ET10.1 in POCTF June through September surface dissolved oxygen concentration and dissolved oxygen saturation concentration, with mean of both (red and green lines).

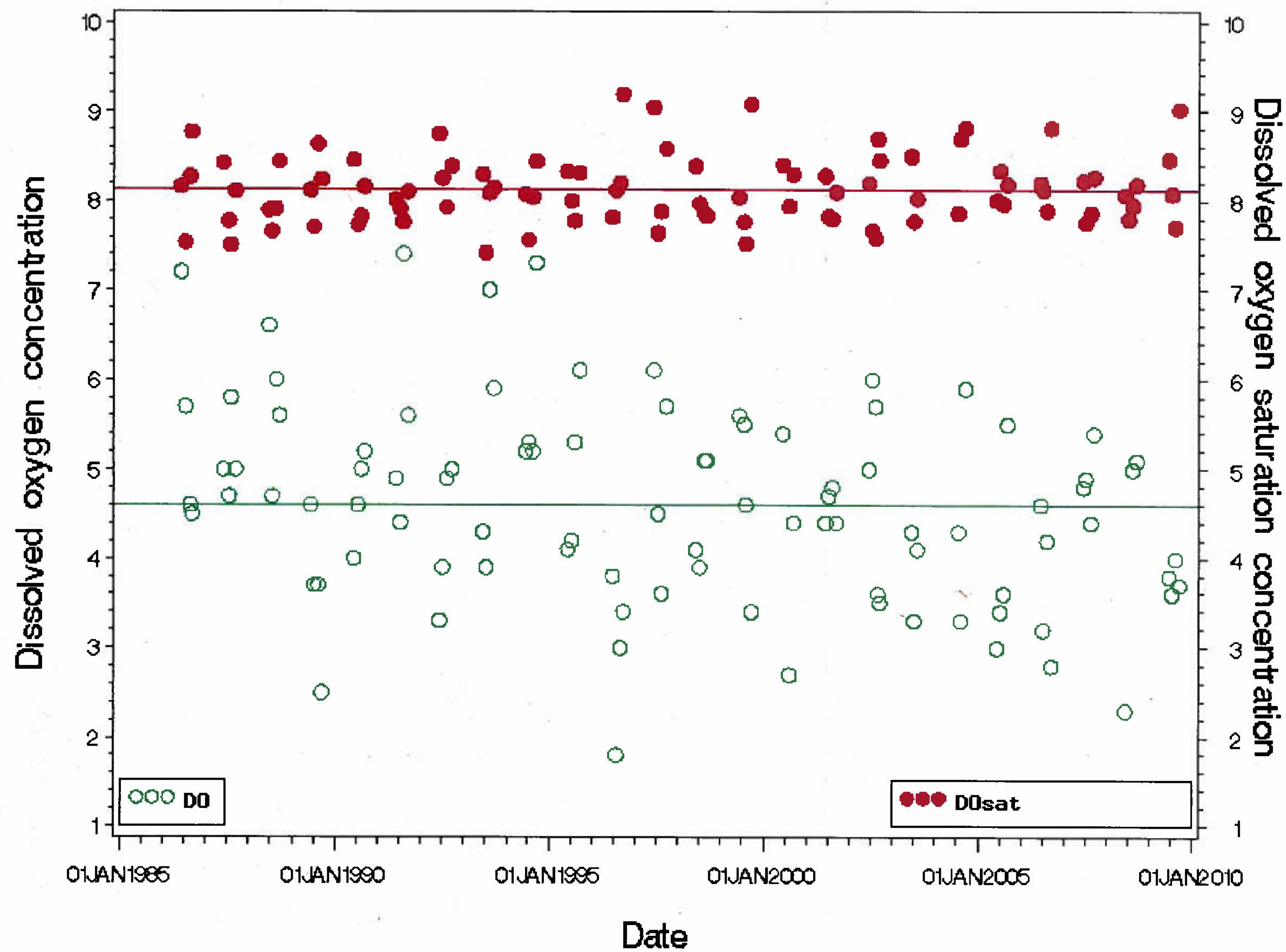

Figure 3. Station ET10.1 in POCTF June through September bottom dissolved oxygen concentration and dissolved oxygen saturation concentration, with mean of both (red and green lines).

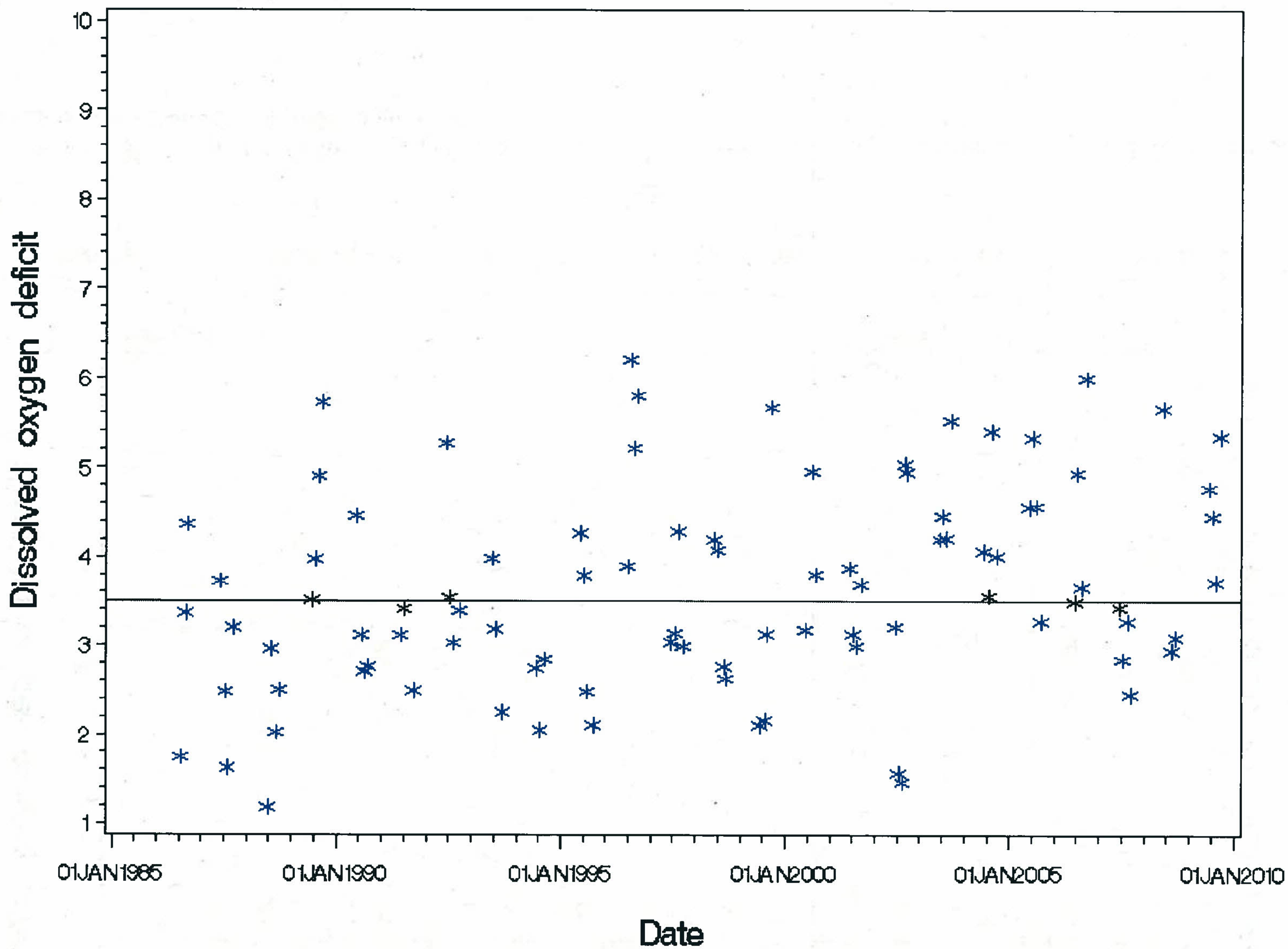

Figure 4. Station ET10.1 in POCTF June through September surface dissolved oxygen deficit, with mean (blue line).

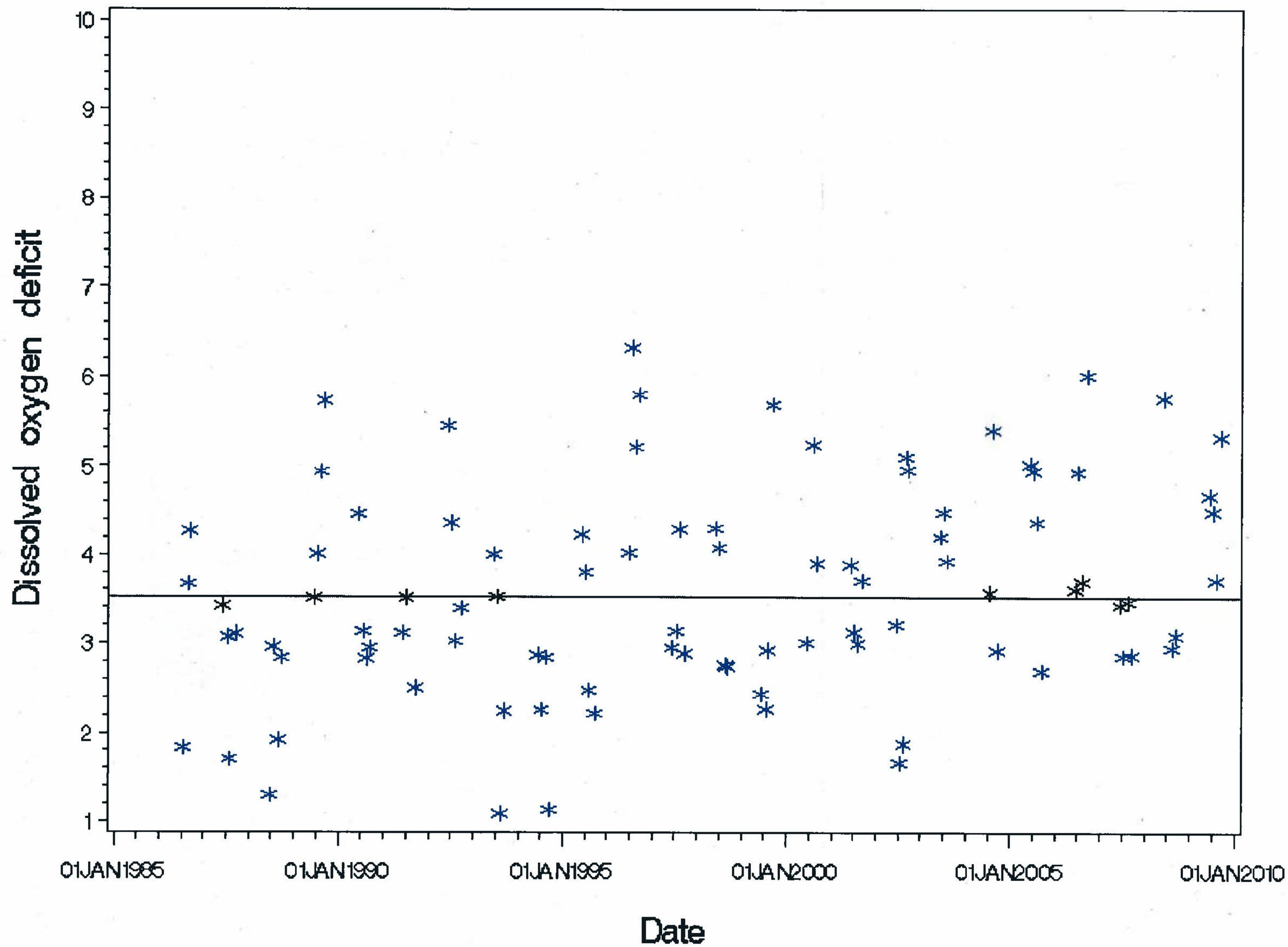

Figure 5. Station ET10.1 in POCTF June through September bottom dissolved oxygen deficit, with mean (blue line).

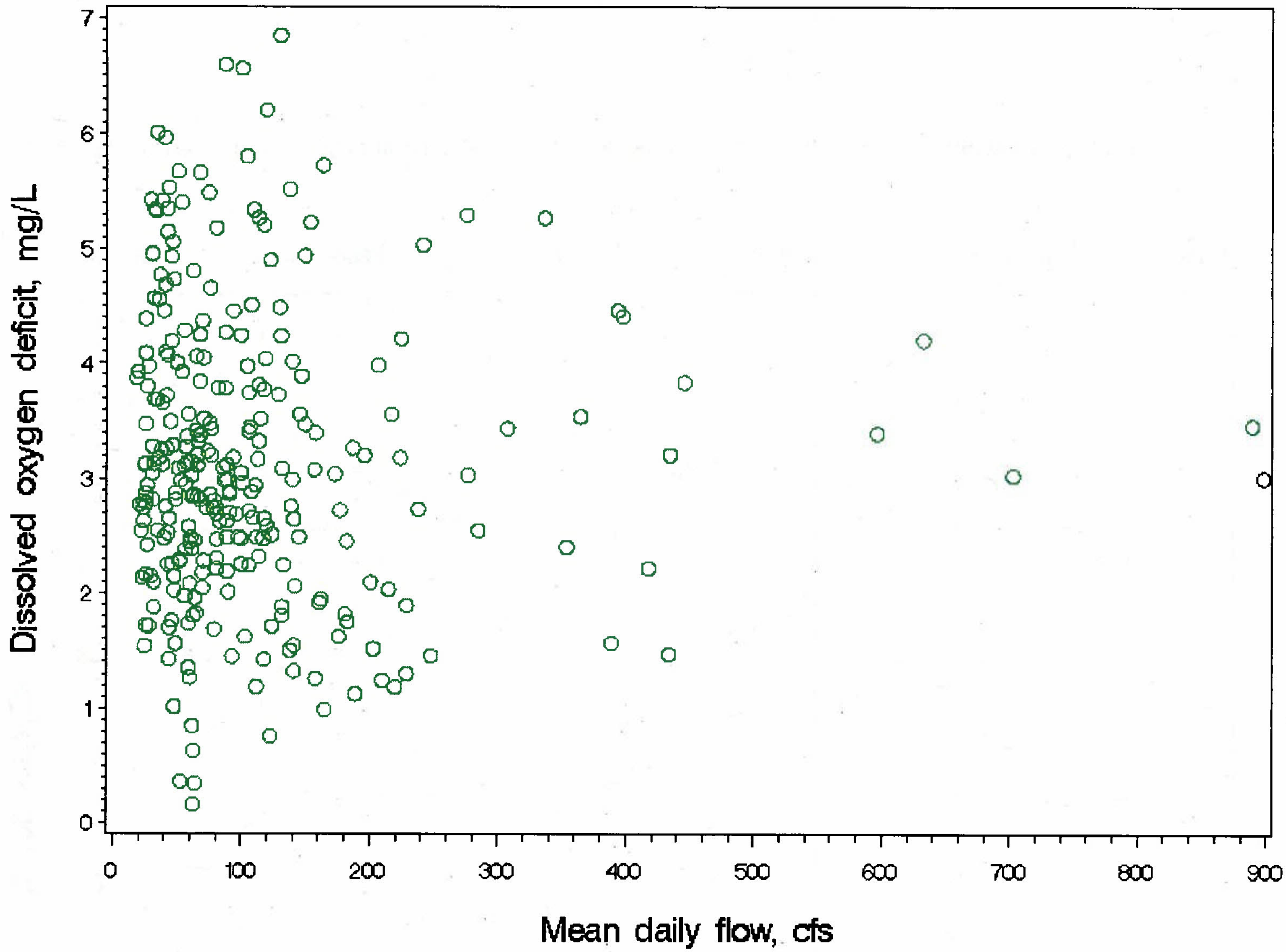

Figure 6. Dissolved oxygen deficit at ET10.1 in POCTF versus Pocomoke River flow measured near Willards, MD.

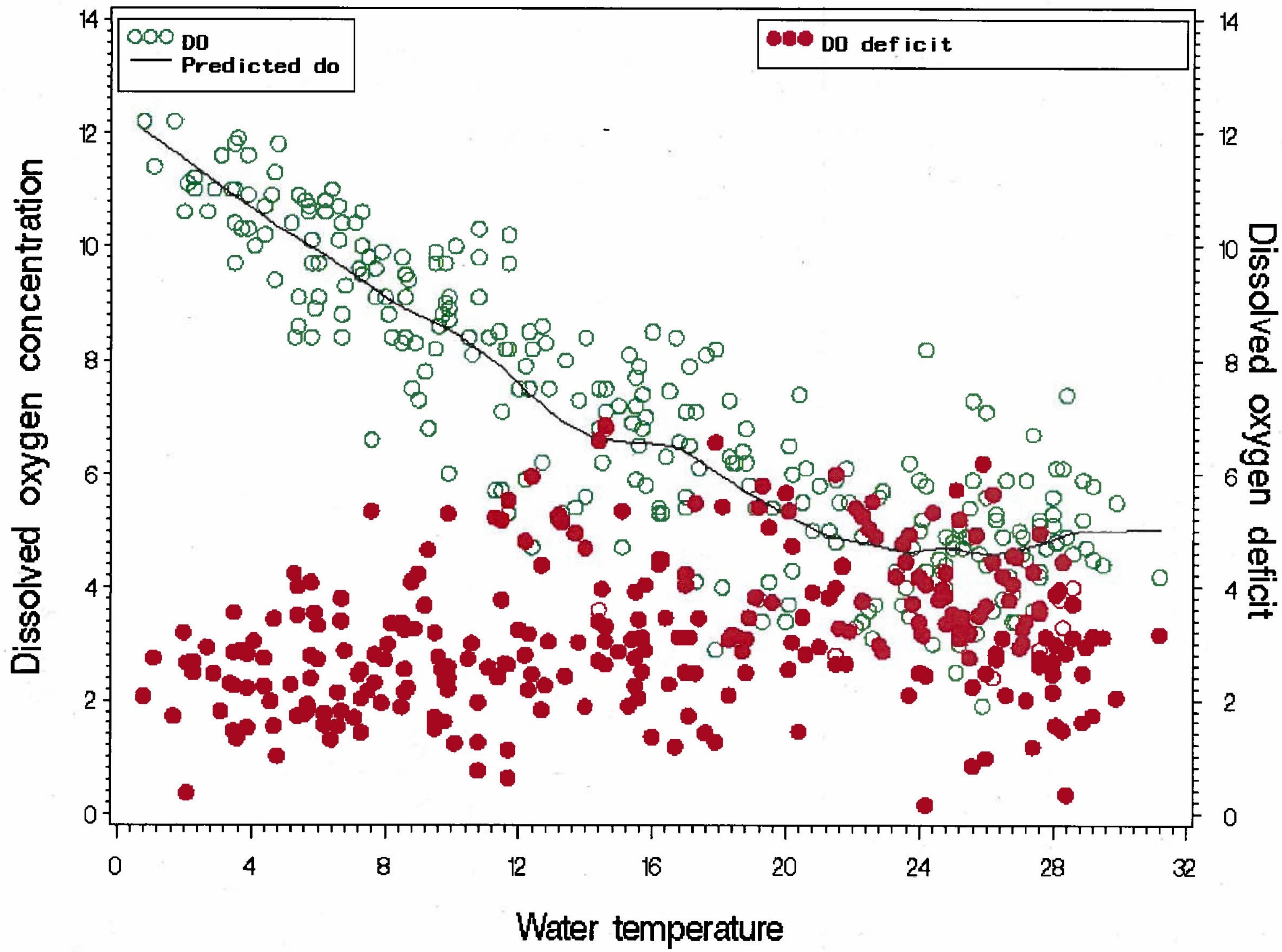

Figure 7. Dissolved oxygen and predicted dissolved oxygen fit with LOESS smooth, with dissolved oxyten deficit as a function of water temperature at ET10.1 in POCTF.

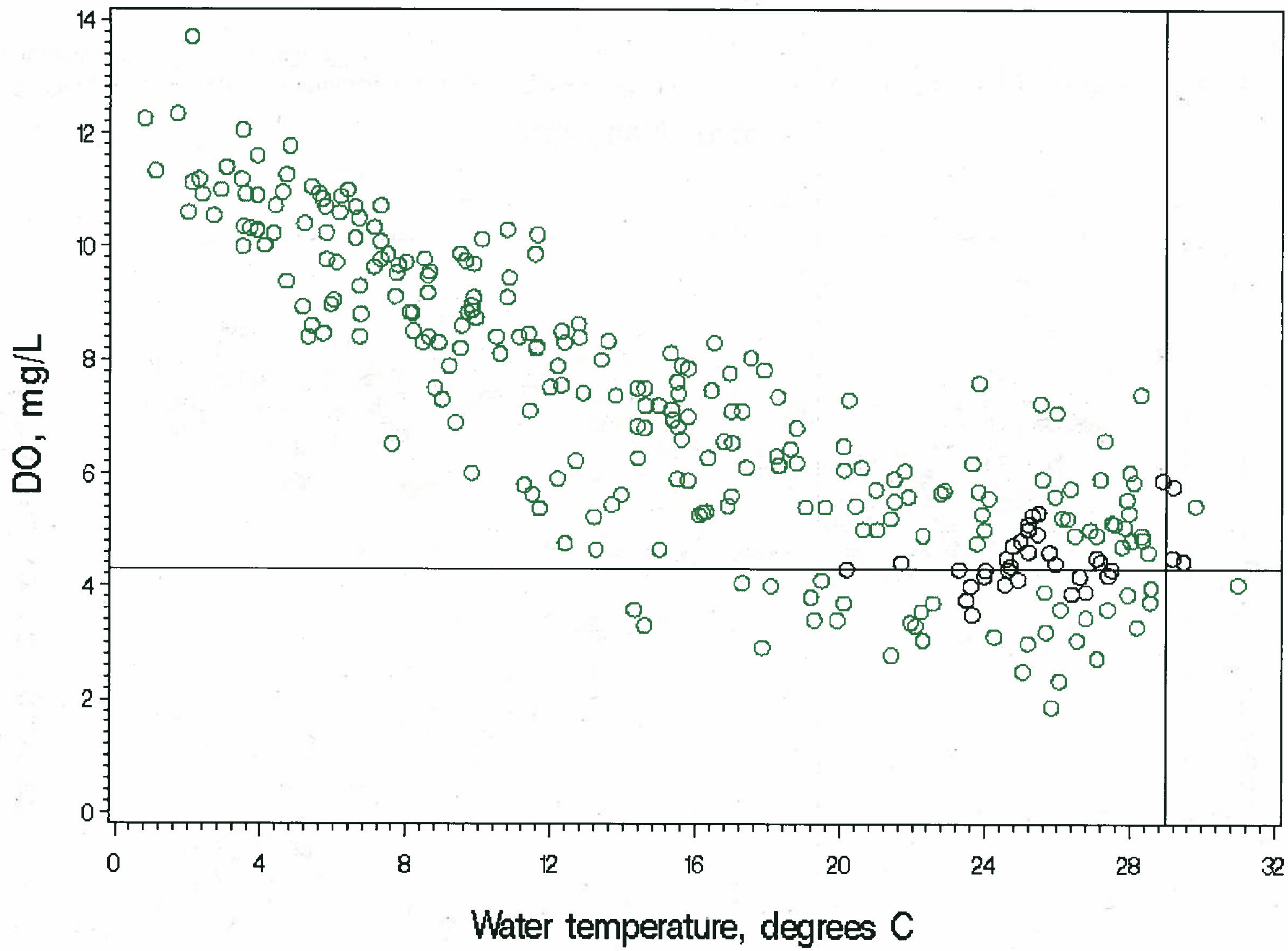

Figure 8. Dissolved oxygen concentrations less than 4.3 mg/L at water temperatures exceeding 29 degrees centigrade using water column averaged data for station ET10.1 in POCTF.